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GAMMA-GAMMA ANGULAR CORRELATION MEASUREMENTS IN THE $^{59}Co(n,\gamma)^{60}Co$ REACTION

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BUDAPEST

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GAMMA-GAMMA ANGULAR CORRELATION MEASUREMENTS IN THE $^{59}Co/n,\gamma/^{60}Co$ REACTION

by

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ABSTRACT

Angular correlation measurements of gamma radiation following thermal neutron capture in ^{59}Co have been performed with a combination of a 10 ccm Ge/Li/ diode and a ϕ 12.7 x 12.7 cm NaI/Tl/ detector. In the decay of ^{60}Co cascades of 6876.6 - 555.7 keV and 6984.6 - 447.2 keV were observed. The spins and parities of the 505 keV and 613 keV levels were found to be 3^+.

РЕЗЮМЕ

Была измерена угловая корреляция гамма-излучения, возникающего при захвате тепловых нейтронов ядрами ^{59}Co, с помощью полупроводникового детектора Ge(Li) объема 10 $см^3$ в сочетании с детектором NaI(Tl) размера Ø12,7 см x 12,7 см. При распаде ^{60}Co были наблюдены каскады с энергиями 6876,6 - 555,7 кэв и 6984,6 - 447,2 кэв. Для спинов и четности уровней энергий 505 кэв и 613 кэв получили значение 3^+.

KIVONAT

A termikus neutronok befogásakor a ^{60}Co atommagok által kibocsátott gamma sugárzás szögkorrelációját mértük 10 cm^3 Ge/Li/ félvezető detektor és ϕ 12,7 x 12,7 cm NaI/Tl/ detektor együttes alkalmazásával. A ^{60}Co bomlásánál 6876.6 - 555.7 keV és 6984.6 - 447.2 keV energiáju kaszkádokat vizsgáltunk. Az 505 keV-es és 613 keV-es nivók spinje és paritása 3^+-nak adódott.

INTRODUCTION

The odd-odd ^{60}Co nucleus is not populated by beta decay, and therefore its excited states can be studied only by nuclear reactions, e.g. /n,γ/ reactions. The previous /n,γ/ studies [1, 2] of ^{60}Co have identified a large number of levels and some spin assignments have been made [3]. The aim of the present experiment was to determine the spin of the 505 and 613 keV levels.

The relevant part of the decay scheme of ^{60}Co is given in Fig. 1.

APPARATUS

In order to obtain a perfect thermal neutron beam a selector was used at one of the horizontal channels of a VVR-S type reactor. During the measurements the reactor yielded about $3.10^6 n/cm^2.s$ thermal neutrons at the target position. The target consisted of 150 mg of metallic cobalt, 10 mm in diam and 0.5 mm thick.

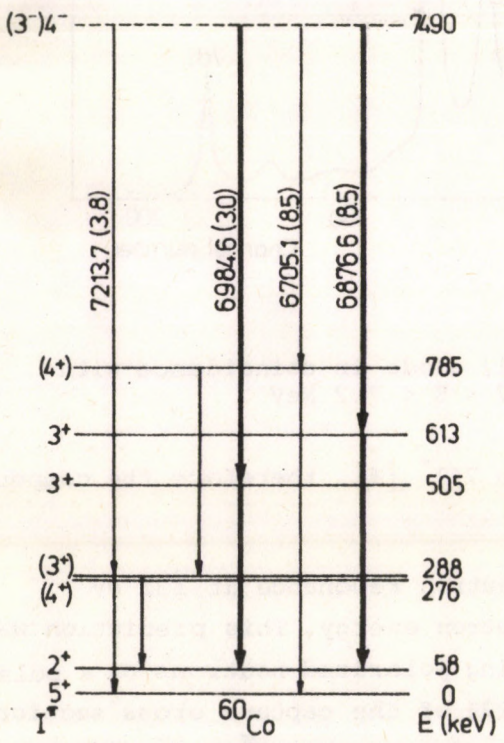

Fig. 1
Partial decay scheme of ^{60}Co

A movable detector with a ϕ 12.7 cm x 12.7 cm NaI/Tl/ crystal on a 58 AVP photomultiplier and a fixed detector with a 10 ccm Ge/Li/ diode were used. The latter detector, in combination with a FET preamplifier, has a resolution of 5.6 keV at 123 keV. The target - detector distance was 13.5 cm for the movable and 8 cm for the fixed detector. The detectors were shielded against background radiation by lead and the target was surrounded by metallic ^6Li.

Pulses from the detectors were fed into a conventional fast-slow coincidence system with a resolving time of $2\tau = 25$ nsec. The pulses from the Ge/Li/ detector were taken into a 512 - channel LABEN analyser, gated by fast - slow coincidences.

Measurements were taken at three angles /90°, 135°, 180°/, with the runs fully automatized.

MEASUREMENTS AND RESULTS

The high energy part of the gamma spectrum from $^{59}Co/n,\gamma/^{60}Co$ was taken with the movable detector. The differential discriminator associated with this detector was set to cover the energy interval $6.7 < E < 7.2$ MeV, which included 6876.6 and 6984.6 keV gamma rays. The coincidence spectrum taken with the Ge/Li/ diode is shown in Fig. 2.

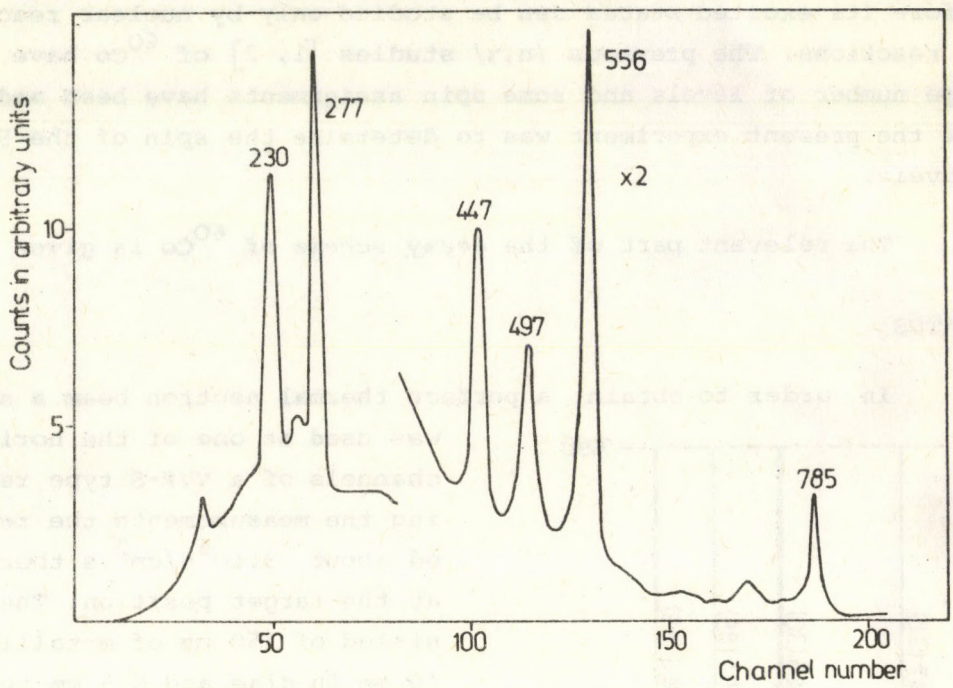

Fig. 2

Spectrum obtained with a 10 ccm Ge/Li/ diode in coincidence with pulses in the range of $6.7 < E < 7.2$ MeV

The ground state of ^{59}Co is $I^{\pi} = 7/2^{-}$ [4], therefore the compound state of ^{60}Co is $J^{\pi} = 3^{-}$ or 4^{-}.

It is expected that the strong neutron resonance at 132 eV $J^{\pi} = 4^{-}$ will dominate at the thermal neutron energy. This prediction was confirmed by a transmission experiment using polarized neutrons on a polarized target [5] according to which about 22% of the capture cross section is due to the $J^{\pi} = 3^{-}$ states and $\approx$ 78% is due to the $J^{\pi} = 4^{-}$ states.

Intense primary transitions from the capturing state to low-energy levels are expected to be E1. Therefore the low-lying levels reached by intense primary gamma rays can have spins and parities of 3^{+}, 4^{+} or 5^{+}.

Therefore both cascades of 6876.6 - 555.7 keV and 6984.6 - 447.2 keV have the same $4^{-}/E\,/4^{+}/E2/2^{+}$ or $4^{-}/E\,/3^{+}/M1+E2/2^{+}$ character, because the 58 keV isomeric state is $J = 2^{+}$, and the intensities of the 555.7 keV and

447.2 keV transitions are relatively high (9.8/100 n capture and 7.3/100 n capture, respectively) thus higher than quadrupole multipolarity is not reasonable.

In the case of the $4^-/1/4^+/2/2^+$ cascade the theoretical angular correlation coefficient would be $A_2 = 0.196$. On the other hand, the experimentally obtained values are:

$A_2 = -0.0144 \pm 0.056$ for the 6984.6 - 447.2 keV cascade and

$A_2 = 0.052 \pm 0.032$ for the 6876.6 - 555.7 keV cascade.

We can conclude therefore that both levels /613 and 505 keV respectively/ have the same spin and parity, namely $J^\pi = 3^+$.

So the transition is $4^-/E1/3^+$ $/M1+E2/2^+$. The theoretical values of A_2 for this transition are plotted as a function of the mixing ratio δ in Fig. 3, together with the experimental values /in an arbitrary abscissa position/. As one can see from this figure, no definite conclusions could be drown as to the value of δ . Taking into account the closeness of the experimental and the theoretical values for $\delta = 0$ and $\delta = \infty$, respectively, very probably both cascades are pure or nearly pure transitions.

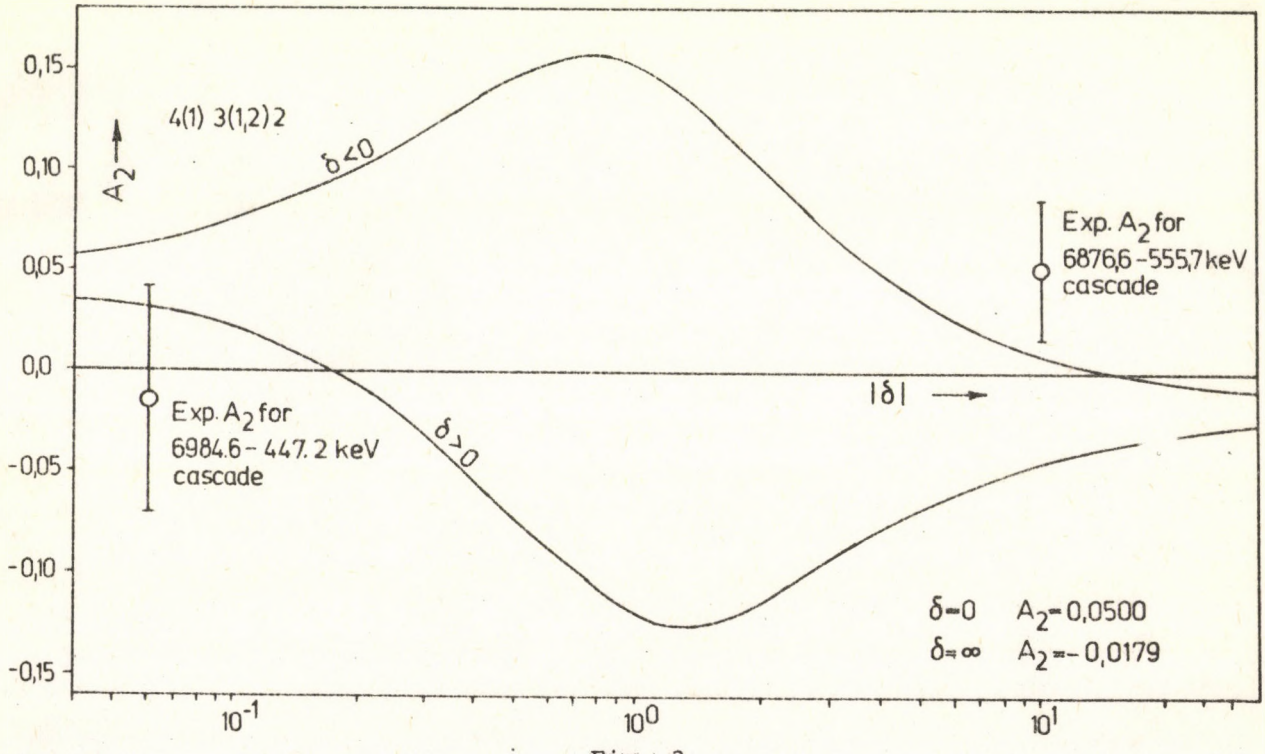

Fig. 3

Theoretical angular correlation coefficient A_2 as a function of E2/M1 mixture δ

These are in agreement with earlier predictions [2] based on intensity relations, and in the case of the 613 keV level with the results of gamma ray circular polarisation measurement.

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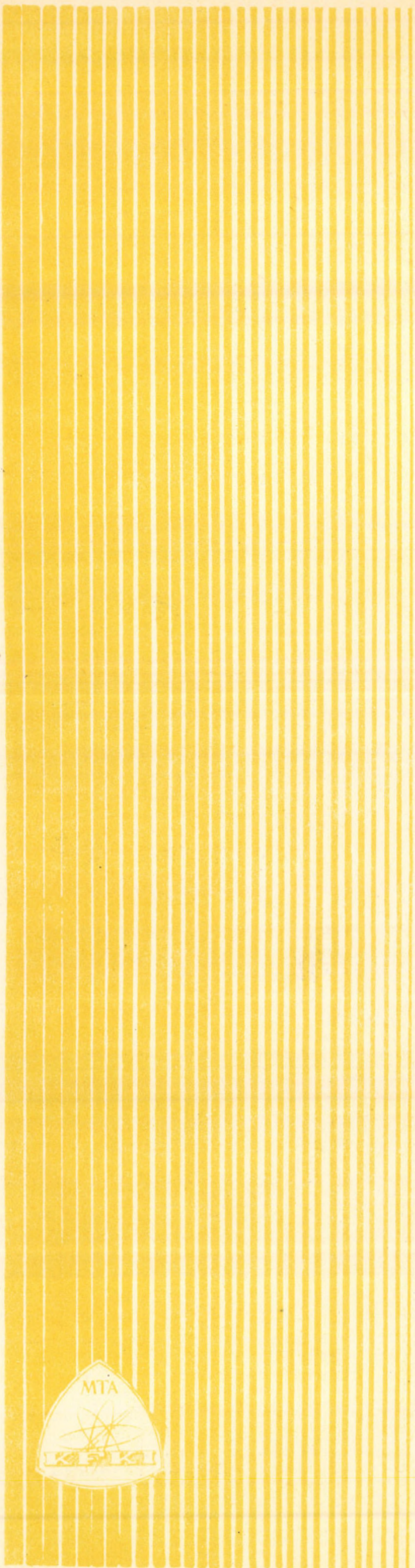

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